REQUEST FOR ACTION (RFA) RESPONSE

GLAST LAT Project
Calorimeter Peer Review 17 – 18 March 2003

Action Item:	CAL – 005
Presentation Section:	Mechanical
Submitted by:	Jim Ryan

Request: CsI logs - Determine stress margins of safety on CsI logs. Need to determine stress allowables and applied loads.

Reason / Comment: Margins of safety for the CsI were not presented.

Addendum to Response: 29 April 2003

There is limited data on the compressive strength of CsI(Tl). In response to the RFA we will measure the compressive strength of a few samples (20 x 27 x 30 mm) of our CsI(Tl) from Amcrys. The test will load the crystal sample against the endcap as in the PEM design. These tests will be executed in the next week and results will be reported. This report may not be available until after CDR. We should note that the EM module just completed qualification level vibration test without mechanical problems. I believe the only issue is perhaps a long-term compressive set that changes the preload. This would not be enough to impact the light yield performance of the crystals.

Response: 25 April 2003

The stress margins of safety on the CsI logs is 0.21. The applied load is 83.1 N over a minimum contact area of 110 mm^2. The stress allowable was determined from the average value of the compression proportional limits published in NASA TM X-64898.

This calculation is summarized in Section 6 of the attached technical note, LAT-TD-02050-01 (LLR-GLAST-TN-083). The attached view graphs, which were presented at the CAL Peer Review, have been updated to address the request of this RFA.

Quasi-Static Analysis

Load Case for Analysis

Load case	Boundary conditions
• 12g X Unidirectional • 12g Y Unidirectional • 12g Z Unidirectional • 7.5g X-Y, 8.5g Z Combined	TX, TY, TZ = 0 For 2 Nodes on Each Tab of the Base Plate (Fastener Positions)

Results

COMPONENT	MATERIAL	YIELD STRENGTH (MPa)	ULTIMATE STRENGTH (MPa)	MARGINS OF SAFETY
Composite Structure	T300 1K/M76	-	564 (1)	21.4
Base Plate	2618A-T851	390	440	7.1
Top Frame	2618A-T851	390	440	67.7
Close-Out Plates	2618A-T851	390	440	6.7
Side Panels	5754 H111	100	220	4.9
Inserts	Ti-6Al-4V	850	1000	4.3 (2)
PCB	Glass/Polyamide	-	89	6.5
CsI Log	Cesium Iodide	1.12	11.86	0.21

NOTES:
(1) Values Have Been Measured on Test Samples, Weave Direction
(2) Calculated for Lateral Inserts Only

Thermo-Mechanical Analysis

Load Case for Analysis

Load case	Boundary conditions
• +30 °C Temperature Increase • -50 °C Temperature Reduction	TZ=0 For the Nodes on the Lower Face ff the Tabs TX=0 For Y Symmetry Plane TY=0 For X Symmetry Plane

Results

COMPONENT	MATERIAL	YIELD STRENGTH (MPa)	ULTIMATE STRENGTH (MPa)	MARGINS OF SAFETY
Composite Structure	T300 1K/M76	-	564 (1)	1.6
Base Plate	2618A-T851	390	440	1.9
Top Frame	2618A-T851	390	440	3.0
Close-Out Plates	2618A-T851	390	440	1.4
Side Panels	5754 H111	100	220	3.1
Inserts	Ti-6Al-4V	850	1000	0.69 (2)
PCB	Glass/Polyamide	-	89	1.9
CsI Log	Cesium Iodide	1.12	11.86	0.21

NOTES:
(1) Values Have Been Measured on Test Samples, Weave Direction
(2) Temperature Reduction of 65 deg Cinstead of 50 deg C

Note Technique / Technical Note		
GLAST	*GLAST LAT CAL Mechanical Structure*	Ref: GLAST-LLR-TN-083 Issue: Draft Date: 21 April 2003 Page : 1

Compression load On the CsI logs

LAT reference : LAT-TD-02050-01

Change History log

					S. Le Quellec	O. Ferreira
Ind.	**Date**	**Modifications**	**Prepared**	**Checked**	**PA Approval**	**Project Approval**

1 SCOPE OF THE DOCUMENT

This document present the load levels on the CsI logs of the CAL module resulting from their assembly inside the mechanical structure and the environmental loads.

2 CDE ASSEMBLY

The CsI logs are mounted inside the cells of the composite structure with silicone elastomeric piece-parts to interface them with the structure. The cords along the chamfers of the logs provide the transverse support of the crystals and a friction force that prevents their longitudinal motion. The bumper frames at each end ensure the longitudinal stop against the closeout plates.
The bumper frames needs to compensate for any clearance between the CsI logs and the closeout plate whatever the length of the crystals is, to avoid any peak load that could result from the motion of a log. The goal is not to guaranty a minimum preload but to ensure that is no clearance left so that the bumper frame can act as a damper for longitudinal vibrations.

3 MECHANICAL PROPERTIES OF CESIUM IODIDE

The mechanical properties of the Cesium Iodide are presented in the table below.

Property	Average	Min	Max
Yield tensile strength (MPa)	1.86	0.73	2.28
Ultimate tensile strength (MPa)	4.05	2.24	11.86
Compression strength (MPa)	1.12	0.28	2.4
Tensile Modulus (MPa)	12100	11000	13500
Compression modulus (MPa)	12000	4000	30000
Shear modulus (Mpa)	6800	6200	7930
Poisson’s ratio	0.26	0.21	0.30
CTE (10^{-6}/°C)	54	-	-
Thermal conductivity (W/m°C)	1.54	-	-
Density (Kg/m^3)	2760	2670	4420

The values are from NASA Technical Memorandum NASA TM X-64741: Scintillator handbook with emphasis on Cesium Iodide (April 13th 1973). Measurements show large variations from sample to sample, particularly on compression strength. The variations can be attributed to flaws in the crystalline structure. They should be related to the position of the sample in the boules and to fabrication process of the vendor.

4 PRELOAD OF THE BUMPER FRAMES

4.1 COMPRESSION PROPERTIES OF THE BUMPER FRAMES

The compression versus load characteristics have been measured on 20 bumper frames from the lot fabricated for the EM model. The testing has been performed by the company ADDIX which is the company in charge of the fabrication. The dimensions and materials are the same as for the flight parts:

- VALOX DR48 PBTP from GE PLASTICS

- 7601B silicone from ADDIX

The samples have been cured 16 hours at 175°C.

Compression (mm)	Load (N)	Confidence 5% risk	RMS (N)
0.05	3.8	+/- 0,7	1.5
0.1	14.6	+/- 2,7	5.9
0.15	23.6	+/- 0,1	0.2
0.2	23.7	+/- 0,1	0.2
0.25	24.8	+/- 0,5	1.0
0.3	34.7	+/- 4,2	9.0
0.35	51.0	+/- 0,8	1.7
0.4	52.8	+/- 0,6	1.2
0.45	53.5	+/- 0,5	1.2
0.5	56.3	+/- 1,9	4.0
0.55	67.1	+/- 7,2	15.5
0.6	85.5	+/- 12,1	25.9
0.7	143.9	+/- 12,7	27.2
0.8	205.0	+/- 12,5	26.6
0.9	264.5	+/- 12,9	27.7
1	329.5	+/- 14,6	31.1
1.1	402.8	+/- 16,6	35.4
1.2	494.5	+/- 20,8	44.5
1.3	605.3	+/- 24,2	51.6
1.4	744.1	+/- 32,4	69.2
1.5	926.3	+/- 42,7	91.3
1.6	1146.0	+/- 53,2	113.7
1.7	1418.3	+/- 66,2	141.5
1.8	1741.7	+/- 79,5	169.9
1.9	2188.0	+/- 101,0	216.2
2	2654.0	+/- 121,0	259.2

4.2 STIFFNESS OF THE CLOSEOUT PLATES

The closeout plates bend between the attachment points as the preload is applied on the bumper frames. A FE structural analysis has been performed to evaluate the deflection. An max value of 0.20 mm has been calculated when considering a constant preload of 20 N from each bumper frame.

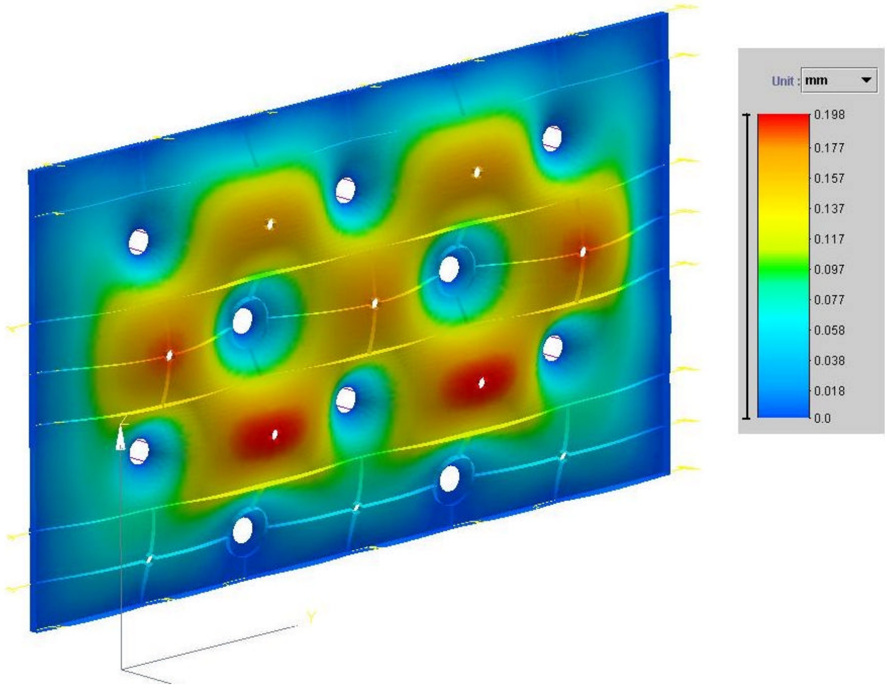

Figure 1: Deflection of the closeout with 20 N preload on the bumpers

4.3 PRELOAD

The variations of the compression load on the bumper frames can be calculated from the min and max dimensions of the parts. The 339 mm dimension on the composite structure defines the closeout plate to closeout plate distance.

Component height	Average	Min	Max
CsI log length in mm	325.7	325.4	326.0
End cap thickness in mm	2.75	2.7	2.8
Bumper frame thickness in mm	4.0	3.9	4.1
Composite structure	338.9	339.0	338.8
Compression per bumper in mm	0.15	0	0.5
Preload in N	23.6	0	56.3

The preload is calculated without taking into account the deflection of the closeout plate. For logs located far from the attachment points of the plate, the max preload would be reduced from 56.3 N to around 28 N. However, close to corners of the plate, the flexibility is very limited and the 56.3 N can be kept as a conservative preload value.

5 LOAD ON THE CSI LOGS

5.1 ACCELERATION OF THE LOGS

The loads on the CsI logs have been recovered from the CAL structural analysis for quasi-static load events. The logs are modeled as beams connected to the closeout plates and the composite walls by linear springs. Assumption has been made that no slippage occurs between a CDE and the corresponding cells: the motion of the log is only the result of the shear strain of the silicone cords and the compression of the bumper frame.

The table below show for each load case the max reaction loads on the X side and Y side logs.

Load	**Log**	**N (N)**	**TY (N)**	**TZ (N)**	**MX (N.mm)**	**MY (N.mm)**	MZ (N.mm)
12GX	X side log	21.48	0.75	2.57	0.00	185.35	89.13
	Y side log	4.03	7.06	2.77	0.00	174.92	233.45
12GY	X side log	3.94	6.95	3.07	0.00	191.18	223.07
	Y side log	25.18	0.73	2.42	0.00	190.14	88.31
12GZ	X side log	6.78	0.88	20.73	0.00	1181.19	62.65
	Y side log	2.59	0.89	20.56	0.00	1165.77	64.31
7,5g X-Y 8,5g Z	X side log	13.34	4.66	14.31	0.00	888.78	181.10
	Y side log	15.03	4.88	14.44	0.00	859.82	202.57

The maximum compression load on the logs is:

$$F = 25.2\ N$$

If the deflection of the closeout plate is not taken into account (conservative approach), the corresponding compression of the bumper frames is:

$$dL = 0.25\ mm$$

5.2 THERMAL EXPANSION OF THE LOGS

The survival temperature of the CAL is +50°C which corresponds to a temperature increase of 30°C from the assembly temperature. The corresponding expansion of the logs is given by:

$$dL = 326 \text{ x } 30 \text{ x } 54\ 10^{-6}$$

$$dL = 0.528\ mm$$

If the deflection of the closeout plate is not taken into account (conservative approach), the corresponding compression load on the bumper frames is:

$$F = 26.8\ N$$

5.3 MAX TOTAL LOAD ON THE CSI LOGS

Thermal loads are slightly higher than launch quasi-static loads. Since both are not applied simultaneously, the max total load on the CsI logs is the sum of the preload and thermal load:

Fmax = 83.1 N

6 MARGINS OF SAFETY

The load at the end of the CsI logs is applied on a reduced area: the contact area between the CDE end cap and the crystal surface. The minimum contact surface is around 110 mm². The corresponding average stress on the CsI material is 0.75 MPa.
If a factor of safety of 1.25 is used, the margin of safety to the compression proportional limit is:

MoS = 0.21

This margin of safety is based on the average value of the compression proportional limit from the NASA TM X-64741 memo. Because of the factor 4 between the min and average values, a permanent set is possible depending on the mechanical properties of the CAL CsI crystals.